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JOHN F. KENNEDY
SPACE CENTER

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ACCEPTANCE TEST, DATA REDUCTION PROCEDURE AND CALCULATION DEFINITIONS USED FOR SEALED, ABSOLUTE, GAGE, AND DIFFERENTIAL STRAIN GAGE PRESSURE TRANSDUCERS

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Prepared by
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SECTION I
INTRODUCTION

1.1 PURPOSE

This document outlines the checkout and performance test requirements, and the definitions of calculations for sealed, absolute, gage, and differential strain gage pressure transducers. The transducing elements, in these transducers, are strain gage bridges incorporating standardized millivolt output. The transducer case and pressure cavities are made of corrosion resistant stainless steel.

1.2 SCOPE

This procedure shall be used by IN-MSD and Contractor personnel for acceptance testing pressure transducers, used for pressure measurements, in support of all Saturn launches. Any deviations from this procedure must be approved, in writing, by the NASA Technical Representative.

The test equipment listed in this document may be substituted, with test equipment of equal quality and accuracy, at the option of the NASA Technical Representative.

NOTE

All test equipment that is used, in support of the procedures herein, shall have a valid in-date NASA KSC CALIBRATION label affixed.

1.3 DEFINITIONS

The following terms are used herein in association with pressure transducers.

PSIA	Pounds per square inch (absolute)
PSID	Pounds per square inch (differential)
PSIG	Pounds per square inch (gage)
PSIS	Pounds per square inch (sealed)

SECTION II
TRANSDUCER INSPECTION

2.1 GENERAL

Each transducer shall be visually inspected prior to testing. Perform the following functions to inspect each transducer.

1. Examine for evidence of physical damage, corrosion, deterioration, damaged electrical connectors, deformed pressure fittings, and poor workmanship.

2. Ensure that all pressure fittings and electrical connectors have protective caps.

3. Verify that the following identification is engraved on the transducer case:

   a. Manufacturer and model number.
   b. KSC specification number.
   c. Contract number.
   d. Pressure range.
   e. Serial number of the unit.
   f. Rated excitation.
   g. Rated overload.
   h. Compensated temperature range.
   i. High port identification (for differential units only).
   j. Reference port identification (for gage units only).

NOTE

The transducer electrical connector shall be a male, 6-pin connector (case mounted), and shall mate with a Bendix PT06P-10-6S mating connector.

4. Annotate any deficiencies noted from the above inspection on the Test and Evaluation Sheet.

SECTION III
TEST EQUIPMENT AND TESTING

3.1 TEST CONDITIONS

Five temperature levels (T_1, T_2, T_3, T_4, and T_5) referenced in table 3-1 shall be used in this procedure. All tests shall be performed at a temperature of 77 ±5° Fahrenheit, unless otherwise specified. All transducer output values shall be obtained with a minimum of 100k ohm load during testing. The type of transducer (cryogenic, standard, or special) requiring implementation of this procedure will be noted on the Support Request.

Table 3-1. Transducer Temperature References

T-Number	Cryogenic	Standard	Special
T_1	-65° F	0°	0°
T_2	*	-65° F	-40° F
T_3	+77° F	+77° F	+77° F
T_4	+165° F	+165° F	+165° F
T_5	+250° F	+250° F	+250° F

* For immersion in LN_2, use -320° F
For Model MK7600SD (Delta Design) temperature chamber, use -295°F

The actual test temperatures shall be monitored during each cycle and the temperature shall be recorded on the Test and Evaluation Sheet (figure 3-1) at the beginning and end of each cycle.

PRESSURE TRANSDUCERS TEST AND EVALUATION

KSC Spec No. . . . . Contract No. . . . . Date . . . .

Manufacturer	Model	Range	Serial No.	Excitation	Channel	Test Lot #

Input Resistance: . . . . Ohms, Pins C & D, @ 77 ± 5° F
Output Resistance: . . . . Ohms, Pins A & B, @ 77 ± 5° F
Insulation Resistance: . . . . . Ohms, Pins A, B, C, D, E, and F to Case, @ 77 ± 5° F, @ 50 Vdc

ZERO STABILITY

Time (minutes)	15	30	45	60
Output (mv)				
Ref Press (inches Hg)				

% Rated Pressure	Output (mv) @ 77 ± 5° F Cycle 1	Cycle 2	Cycle 3
0%	A_1	A_2	A_3
20%	B_1	B_2	B_3
40%	C_1	C_2	C_3
60%	D_1	D_2	D_3
80%	E_1	E_2	E_3
100%	F_1	F_2	F_3
80%			
60%			
40%			
20%			
0%	L_1	L_2	L_3

	Cycle 1	Cycle 2	Cycle 3
Sensitivity	S_1____ mv	S_2____ mv	S_3____ mv
Zero Balance	____ %FS	____ %FS	____ %FS
Non-Linearity	____ %FS	____ %FS	____ %FS
Hysteresis	____ %FS	____ %FS	____ %FS
Nonreturn to Zero	____ %FS	____ %FS	____ %FS
Non-Repeatability	____ %FS		
Accuracy	____ %FS		
Zero Stability	____ %FS		
Average Sensitivity (S_A)	____ mv		

Temp	Thermal Sensitivity Shift %FS/° F	Thermal Zero Shift %FS/° F
T_1		
T_2		
T_4		
T_5		

TECH STAMP . . . . . Thermal Hysteresis . . . . . . %FS

% Rated Pressure	Output mv @ T_1	T_2	T_3	T_4	T_5	T_3
Temp (° F) 0% . . . . Output (mvdc)	$\phi 1$	$\phi 2$	$\phi 3$	$\phi 4$	$\phi 5$	$\phi 6$
Temp (° F) 100% . . . . Output (mvdc)	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6

TEST EQUIPMENT

Equipment	Manufacturer	Model	Z-Number	Cal Due

Figure 3-1. Test and Evaluation Sheet

3.2 TEST EQUIPMENT

All tests shall be performed using the following test equipment or that specified in the individual paragraphs of this procedure. All equipment substitutions must be approved by the NASA Technical Representative.

a. Readout Devices.

Cimron Model 7650 DVM (with ohms converter)

Hewlett/Packard Model 2401(B or C) DVM (with ohms converter)

Hewlett/Packard Model 3450A DVM (with ohms converter)

Fluke Model 8300A (with ohms converter)

Fluke Model 883AB Differential Voltmeter

b. Power Supplies.

Power Design Model 5005R

Power Design Model 5005S

c. Pressure Sources / Controls / Monitors.

Dead weight gage, Ruska Model 2450.2M, accuracy 0.015% of reading

Dead weight gage, Ruska Model 2465, accuracy 0.015% of reading

Quartz null gage, Texas Instruments Model 141, accuracy 0.05% of reading

Controller, CEC Model 6-301, with associated pressure heads, accuracy 0.025% of pressure head full scale

Vacuum gage, Hastings Model VT6, accuracy ±1%

d. Miscellaneous.

Vacuum pump, Welch Duo Seal, vacuum capability 0.1 microns of mercury

Test Console, manifold, switching panel, and patch panel (figure 3-2)

Insulation tester, GR Model 1644A, Megohm Bridge, accuracy ±1%

Temperature chamber, Delta Design Model MK 7600SD, control tolerance of ±0.5° F

Digital thermometer, United Systems Model 251/551-3

Temperature potentiometer (with copper-constantan thermocouple), Leeds and Northrup Model 8695

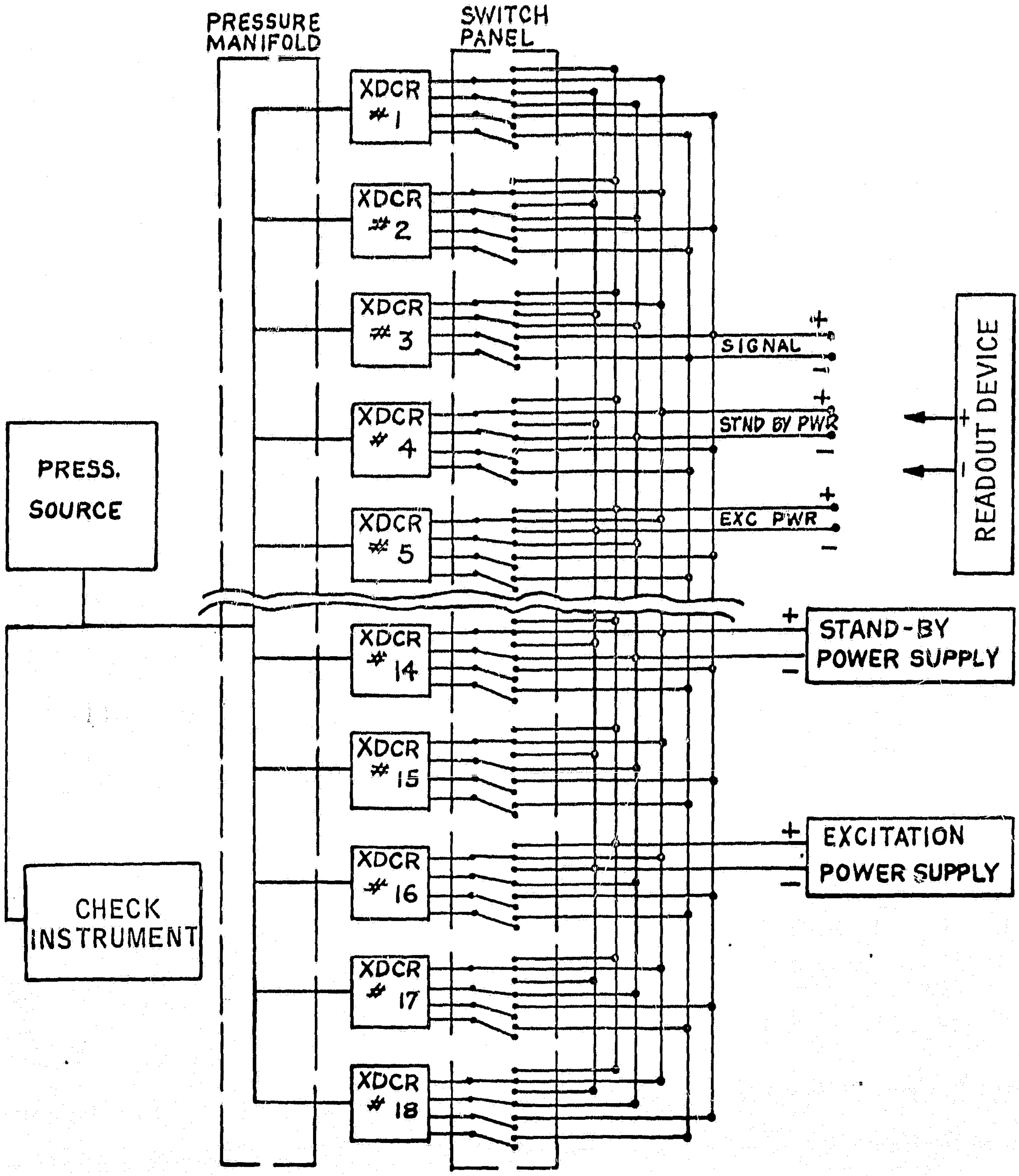

Figure 3-2. Test Equipment Setup

3.3 PERFORMANCE TESTS

The resistance and calibration tests outlined in paragraphs 3.3.1 through 3.3.4 shall be performed on each transducer.

3.3.1 Input Resistance

1. Connect the multimeter across connector pins D and C.
2. Measure the input resistance of the transducer.
3. Record the input resistance value on the Test and Evaluation Sheet.

3.3.2 Output Resistance

1. Connect the multimeter across connector pins A and B.
2. Measure the output resistance of the transducer.
3. Record the resistance value on the Test and Evaluation Sheet.

3.3.3 Insulation Resistance

NOTE

Do not measure between connector pins.

1. Adjust the test potential on the insulation tester (GR Model 1644A) to 50 volts dc.
2. Connect the negative lead of the insulation tester to the connector case.
3. Connect the positive lead from the insulation tester to all pins paralleled together.
4. Measure the insulation resistance and record the value on the Test and Evaluation Sheet.

3.3.4 Functional Calibration

NOTE

For a bidirectional differential transducer, vent the low port to atmosphere and perform gage type transducer test; then vent the high pressure port to atmosphere and repeat tests. Use separate Test and Evaluation Sheet for each pressure port test series.

Transducers with the equivalent of up to 100 psia full scale pressure range shall be calibrated on a Quartz Null Gage (Texas Instruments Model 141, or a Ruska Model 2465 Dead Weight Tester).

Transducers with the equivalent of up to 500 psia pressure range shall be calibrated with a Quartz Null Gage (Texas Instruments Model 141, or a Ruska Model 2465 Dead Weight Tester).

Ruska Dead Weight System (Ruska Model 2450.2M) shall be used to calibrate transducers with ranges up to 15,000 psia, provided the proper correction factors are used (step 1).

NOTE

During all tests below 500 psi the CEC Model 6-301 Pressure Controller shall be used as a check instrument connected to the same manifold as the transducer being tested (refer to figure 3-2).

1. Utilize the following correction factors for Ruska Dead Weight System:

   a. Temperature Correction

$$A_o\,(t + \Delta t) = A_o\,(t = 25)\,(1 + C\,\Delta t)$$

Where:

$A_o\,(t + \Delta t)$ = effective area of piston corrected to working temperature

$A_o\,(t = 25)$ = area of piston at zero psig and at the reference temperature of 77^o F as given in the calibration data of the Ruska Dead Weight System

C = coefficient of superficial expansion as indicated in the calibration data of the Ruska Dead Weight System

Δt = difference between working temperature and 77^o F

   b. Elastic Distortion

$$A_e = A_o\,(1 + bp)$$

Where:

A_e = effective piston area at pressure p

A_o = effective piston area at zero psig and the reference temperature of 77^o F as given in the calibration data of the Ruska Dead Weight System

b = fractional change in area per unit change in pressure as given in calibration data of the Ruska Dead Weight System

p = operating pressure

   c. Grav'.y and Buoyancy

$$W = Ma \left(\frac{\text{local gravity}}{980.665}\right) \times \left[1 - \left(\frac{0.0012}{8.4}\right)\right]$$

Where: W = weight load

Ma = apparent mass as given in calibration data of Ruska Dead Weight System

local gravity = local gravity in cm/sec^2

2. Connect the transducer pressure port to the pressure manifold.

3. Connect the transducer per test equipment setup (figure 3-2).

4. With the EXCITATION/OUTPUT switch in the EXCITATION position, adjust the excitation voltage to 10 volts dc ±0.01 volt.

5. Verify that the excitation voltage is stable within ±0.005 volts dc, and turn the EXCITATION/OUTPUT switch to the OUTPUT position.

6. Maintain a constant pressure as applicable:

Apply 14.7 psia for psis-type transducers.
Apply 0 psig for psig and psid-type transducers.
Apply 200 microns or less for psia-type transducers.

7. Fifteen minutes after application of excitation to the transducer record the output voltage on the Test and Evaluation Sheet. Continue to monitor and record the transducer output at 15-minute intervals for 1 hour. Monitor and record the pressure of the reference source.

8. Maintain the transducer temperature at 77 ±5° F.

9. Verify that the excitation voltage is stable within ±0.005 volts dc, and turn the EXCITATION/OUTPUT switch to the OUTPUT position.

NOTE

Exercise differential transducers twice (0 to FS, and back to 0) on the test port prior to performing Step 10. (Gage, absolute, and sealed transducers <u>shall not</u> be exercised prior to testing.)

10. Apply input pressure to the transducer for five equally spaced pressure increments increasing, and five equally spaced increments decreasing (through the full pressure range of the transducer undergoing test). Perform this calibration three times for repeatability and accuracy calculations.

11. Measure the transducer output at the specified input pressures for each of the three calibration cycles, and record on the Test and Evaluation Sheet. In addition, record the check instrument output on the Check Instrument Data Sheet (figure 3-3).

12. Install the transducer in the temperature test chamber (Delta Design Model MK 7600SD, or approved equivalent). Adjust to maintain T_1 ±5° F temperature (refer to table 3-1), and allow 1 hour for the transducer to achieve thermal stability.

13. Apply input pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

14. Adjust the temperature test chamber to maintain T_2 temperature within the range of -1° F and +10° F (alternate for cryogenic transducers - immerse in liquid nitrogen). Allow 1 hour for the transducer to achieve thermal stability.

15. Apply pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

16. Adjust the temperature test chamber to maintain T_3 ±5° F temperature (refer to table 3-1), and allow 1 hour for the transducer to achieve thermal stability.

17. Apply input pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

18. Adjust the temperature test chamber to maintain T_4 ±5° F temperature, and allow 1 hour for the transducer to achieve thermal stability.

19. Apply input pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

20. Adjust the temperature test chamber to maintain T_5 temperature within the range of +0° F and -5° F, and allow 1 hour for the transducer to achieve thermal stability.

21. Apply input pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

22. Adjust the temperature test chamber to maintain T_3 ±5° F temperature, and allow 1 hour for the transducer to achieve thermal stability.

23. Apply input pressure to the transducer for 0% and 100% pressure increments. Measure the output voltage at each pressure level and record on the Test and Evaluation Sheet.

Check Instrument . . . . Date. . . . .

Manufacturer. . . . . Model. . . . .

Serial Number . . . . Test Lot Number . . . .

Range . . . .

ZERO STABILITY

Time (minutes)	15	30	45	60
Output (vdc)				
Reference Press (inches Hg)				

OUTPUT CALIBRATION

Percent of Rated Press	OUTPUT (vdc) at 77 ± 5° F Cycle 1	Cycle 2	Cycle 3
0%	______	______	______
20%	______	______	______
40%	______	______	______
60%	______	______	______
80%	______	______	______
100%	______	______	______
80%	______	______	______
60%	______	______	______
40%	______	______	______
20%	______	______	______
0%	______	______	______

Percent of Rated Press	Temperature Level T_1	T_2	T_3	T_4	T_5	T_3
temp(0°F) 0% . . . . output(vdc)						
temp(0°F) 100% . . . . output(vdc)						

Remarks:

TECH STAMP . . . .

Figure 3-3. Check Instrument Data Sheet

SECTION IV
DATA REDUCTION

4.1 DATA REDUCTION PROCEDURE AND CALCULATION DEFINITIONS

The following Data Reduction Procedure and Calculation Definitions are to be used for sealed, absolute, gage, and differential strain gage pressure transducers. They shall be employed by IN-MSD for acceptance testing pressure transducers used for pressure measurements in support of all Saturn launches.

4.1.1 Sensitivity

1. Calculate the full scale sensitivity of the transducer by determining the algebraic difference in output between 0% and 100% rated pressure. This calculation shall be made using the data recorded in paragraph 3.3.4, step 11, as follows.

$$S_i = F_i - \left(\frac{A_i + L_i}{2} \right)$$

$$S_A = \frac{S_1 + S_2 + S_3}{3}$$

S_i = sensitivity of i^{th} cycle

S_A = average sensitivity

A_i = first zero of i^{th} cycle (figure 3-1)

F_i = full scale output of i^{th} cycle (figure 3-1)

L_i = last zero of i^{th} cycle (figure 3-1)

NOTE

Subscript: i denotes the particular cycle (1, 2, or 3).

2. Record the calculated results on the Test and Evaluation Sheet (figure 3-1).

4.1.2 Zero Balance

1. Determine the transducer output at 0% rated pressure as a percentage of the sensitivity (obtained in paragraph 4.1.1, step 1) as follows.

$$Z.B.\% = 100 \frac{A_i + L_i}{2S_i}$$

Where:

S_i = transducer sensitivity of the i^{th} cycle in millivolts at 77 ±5° F (obtained from paragraph 4.1.1, step 1)

A_i = transducer output of the i^{th} cycle in millivolts with 0% input at beginning of cycle (from data recorded in paragraph 3.3.4, step 11)

L_i = transducer output of the i^{th} cycle in millivolts with 0% input at end of cycle

NOTE

Subscript: i denotes the particular cycle. (1, 2, or 3).

2. Record the results on the Test and Evaluation Sheet (figure 3-1).

4.1.3 Non-Linearity

1. Calculate the following points from the data recorded in paragraph 3.3.4, step 11.

Cycle 1

$$Y_{11} = .2\,(F_1 - A_1) + A_1 - B_1$$

$$Y_{12} = .4\,(F_1 - A_1) + A_1 - C_1$$

$$Y_{13} = .6\,(F_1 - A_1) + A_1 - D_1$$

$$Y_{14} = .8\,(F_1 - A_1) + A_1 - E_1$$

Cycle 2

$$Y_{21} = .2\,(F_2 - A_2) + A_2 - B_2$$

$$Y_{22} = .4\,(F_2 - A_2) + A_2 - C_2$$

$$Y_{23} = .6\,(F_2 - A_2) + A_2 - D_2$$

$$Y_{24} = .8\,(F_2 - A_2) + A_2 - E_2$$

Cycle 3

$$Y_{31} = .2\,(F_3 - A_3) + A_3 - B_3$$

$$Y_{32} = .4\,(F_3 - A_3) + A_3 - C_3$$

$$Y_{33} = .6\,(F_3 - A_3) + A_3 - D_3$$

$$Y_{34} = .8\,(F_3 - A_3) + A_3 - E_3$$

Where: $A_1\ A_2\ A_3$, $B_1\ B_2\ B_3$, $C_1\ C_2\ C_3$, $D_1\ D_2\ D_3$, $E_1\ E_2\ E_3$, and $F_1\ F_2\ F_3$

$S_1\ S_2\ S_3$ are as shown in figure 3-1.

2. Select the largest number in magnitude from Y_{11}, Y_{12}, Y_{13}, Y_{14}.

3. Calculate the percentage of non-linearity (cycle 1) as follows:

$$\% \text{ Non-linearity (cycle 1)} = \frac{100\, Y_1 \max}{S_1}$$

Record this percentage on the Test and Evaluation Sheet (figure 3-1).

4. Select the largest number in magnitude from Y_{21}, Y_{22}, Y_{23}, Y_{24}.

5. Calculate the percentage of non-linearity (cycle 2) as follows:

$$\% \text{ Non-linearity (cycle 2)} = \frac{100\, Y_2 \max}{S_2}$$

Record this percentage on the Test and Evaluation Sheet (figure 3-1).

6. Select the largest number in magnitude from Y_{31}, Y_{32}, Y_{33}, Y_{34}.

7. Calculate the percentage of non-linearity (cycle 3) as follows:

$$\% \text{ Non-linearity (cycle 3)} = \frac{100\, Y_3 \max}{S_3}$$

Record this percentage on the Test and Evaluation Sheet (figure 3-1).

4.1.4 Hysteresis

1. Calculate the magnitude of the difference of the output voltage between the increasing and decreasing pressure excursion for each pressure increment (from the data recorded in paragraph 3.3.4, step 11). An example of calculation follows.

$$|\Delta_i| = (b_i - c_i) \text{ magnitude}$$

Where: $|\Delta_i|$ = magnitude of output difference of increasing and decreasing pressure excursion for the i^{th} pressure increment

b_i = transducer output for the i^{th} pressure increment on the increasing pressure excursion

c_i = transducer output for the i^{th} pressure increment on the decreasing pressure increments

i = the particular pressure increment of interest (1, 2, 3, 4, or 5)

Increment 1 corresponds to 20% pressure input.
Increment 2 corresponds to 40% pressure input.
Increment 3 corresponds to 60% pressure input.
Increment 4 corresponds to 80% pressure input.
Increment 5 corresponds to 100% pressure input.

2. Convert the maximum hysteresis error to a percentage of the full scale sensitivity for each of the three calibration cycles. An example of calculation follows.

$$\text{Hysteresis \%} = 100 \frac{|\Delta_i|}{S_i} \quad \text{max}$$

Where:

S_i = transducer sensitivity in millivolts at 77 ±5° F for the i^{th} cycle (from paragraph 4.1.1, step 1)

$|\Delta_i|$ max = the maximum hysteresis error calculated (in paragraph 4.1.4, step 1) for the i^{th} calibration cycle

NOTE

Subscript: i denotes the particular cycle (1, 2, or 3).

3. Record the results on the Test and Evaluation Sheet (figure 3-1).

4.1.5 Non-Repeatability

1. Calculate the difference in output at identical input pressure for the three calibration cycles (from the data recorded in paragraph 3.3.4, step 11) as follows.

$$\Delta_k = b_{ik} - c_{jk}$$

Where:

Δ_k = the difference in output of the i^{th} calibration cycle and the j^{th} calibration cycle for each transducer at the k^{th} input pressure increment

b_{ik} = the transducer output on the i^{th} calibration cycle at the k^{th} input pressure increment

c_{jk} = the transducer output on the j^{th} calibration cycle at the k^{th} input pressure increment

NOTE

Subscripts: i and j denote the particular cycle with i and j not being the same cycle.

These values shall be calculated for the increasing pressure excursion portion of the calibration cycles, and then the decreasing pressure excursion portion of the calibration cycles.

2. Determine the maximum output difference Δ_k from paragraph 4.1.5, step 1.

3. Convert the maximum millivolt difference to a percentage of the full scale as follows.

$$\text{Repeatability \%} = 100 \frac{\Delta_k}{S_A}$$

Where:

S_A = average transducer sensitivity in millivolts at 77 ±5° F for three cycles (from paragraph 4.1.1, step 1)

Δ_k = maximum millivolt difference (of paragraph 4.1.5, step 2)

4. Record the result on the Test and Evaluation Sheet (figure 3-1).

4.1.6 Nonreturn to Zero

1. Calculate the difference in output at zero psi input pressure for each of the three calibration cycles (from the data obtained of paragraph 3.3.4, step 11) using the following calculation.

$$\Delta_i = A_i - L_i$$

Where:

Δ_i = difference in zero psi output for the i^{th} calibration cycle

A_i = output in millivolts at 0% input pressure at the beginning of the i^{th} calibration cycle

L_i = output in millivolts at 0% input pressure at the end of the i^{th} calibration cycle

NOTE

Subscript: i denotes the particular cycle (1, 2, or 3).

2. Determine the maximum difference in output at 0% input pressure from the calculations of paragraph 4.1.6, step 1.

3. Convert the maximum millivolt difference of paragraph 4.1.6, step 2, to a percentage of full scale sensitivity as follows.

$$\text{Nonreturn to zero \%} = 100 \frac{\Delta}{S_i}$$

Where:

S_i = transducer sensitivity in millivolts at 77 ±5° F for the i^{th} cycle (paragraph 4.1.1, step 1)

Δ = maximum millivolt difference (paragraph 4.1.6, step 2)

4. Record the results on the Test and Evaluation Sheet (figure 3-1).

4.1.7 Accuracy

The accuracy figure shall be the sum of the worst case linearity, hysteresis, and non-repeatability figures previously calculated. Record this sum on the Test and Evaluation Sheet.

4.1.8 Thermal Sensitivity Shift

1. Calculate the thermal sensitivity shift at each temperature point using the sensitivity value S_A obtained in paragraph 4.1.1, step 1.

2. Calculations are performed using the following formula.

$$\text{Sensitivity shift \% FS/° F} = 100 \frac{(Y_i - \emptyset_i) - S_A}{S_A \quad \Delta_t}$$

Where:

S_A = average transducer sensitivity at original +77° F for the three cycles from paragraph 4.1.1, step 1

$(Y_i - \emptyset_i)$ = transducer sensitivity at test temperature

NOTE

Subscript: i denotes the particular temperature cycle (1, 2, 3, 4, 5, or 6) from figure 3-1.

Δ_t = temperature change (°F) from 77 ±5° F to test temperature

3. Record the thermal sensitivity shift on the Test and Evaluation Sheet.

4.1.9 Thermal Zero Shift

1. Calculate the thermal zero shift using the outputs obtained at 0% input pressure during the calibrations recorded in paragraph 3.3.4, steps 12 through 23.

2. Calculations are performed using the following formula.

$$\text{Zero shift \% FS/° F} = 100 \frac{\phi_i - \alpha_1}{S_A \, \Delta_t}$$

Where:

S_A = average transducer sensitivity at original 77 ±5° F for the three cycles from paragraph 4.1.1, step 1

ϕ_i = transducer 0% output at i^{th} test temperature

$\alpha_1 = \frac{A_3 + L_3}{2}$ from Test and Evaluation Sheet (figure 3-1)

Δ_t = temperature change (° F) from 77 ±5° F to test temperature

NOTE

Subscript: i denotes the particular temperature cycle (1, 2, 3, 4, 5, or 6) from figure 3-1.

3. Record the thermal zero shift on the Test and Evaluation Sheet.

4.1.10 Zero Stability

1. Calculate the difference in output between the output at the 15-minute incremental time readings recorded in paragraph 3.3.4, step 7. An example of the calculation follows.

$$\Delta_i = b - c_i$$

Where:

Δ_i = the output difference between initial output (of paragraph 3.3.4, step 7), and subsequent 15-minute readings

b = initial transducer output in millivolts as recorded from paragraph 3.3.4, step 7

c_i = transducer output in millivolts at the i^{th} 15-minute intervals as recorded from paragraph 3.3.4, step 7

NOTE

Subscript: i denotes the particular 15-minute time increment (1, 2, 3, or 4).

2. Determine the maximum difference in output from the initial readings from paragraph 4.1.10, step 1.

3. Convert the maximum output difference of paragraph 4.1.10, step 2, to a percentage of full scale sensitivity as follows.

$$\text{Zero stability \%} = 100 \frac{\Delta_i \max}{S_A}$$

Where:

S_A = average transducer sensitivity at original 77° F for the three cycles (from paragraph 4.1.1, step 1)

$\Delta_i \max$ = maximum output difference in millivolts as recorded in paragraph 4.1.10, step 2

4. Record this value on the Test and Evaluation Sheet (figure 3-1).

4.1.11 Thermal Hysteresis

1. Calculate the transducer balance difference between the calibration before and after temperature excursion as follows.

$$b = \alpha_1 - \phi_6$$

Where:

b = difference in millivolts of balance before and after temperature excursion

$\alpha_1 = \dfrac{A_3 + L_3}{2}$ from the Test and Evaluation Sheet (figure 3-1)

ϕ_6 = transducer output in millivolts for a 0% pressure increment at 77 ±5° F (as recorded in paragraph 3.3.4, step 23) for the final cycle

2. Convert the balance error (recorded in paragraph 4.1.11, step 1) to a percentage of full scale sensitivity before the temperature excursion as follows.

$$\text{Thermal hysteresis \%} = 100 \frac{b}{S_A}$$

Where: S_A = average transducer sensitivity in millivolts at 77 ±5° F for the three cycles (from paragraph 4.1.1, step 1)

3. Record these results on the Test and Evaluation Sheet (figure 3-1).

APPROVAL

Revision 1, GP-564

ACCEPTANCE TEST, DATA REDUCTION PROCEDURE AND CALCULATION DEFINITIONS USED FOR SEALED, ABSOLUTE, GAGE, AND DIFFERENTIAL STRAIN GAGE PRESSURE TRANSDUCERS

ORIGINATOR:

D. Lovall

D. Lovall
Transducer Systems Section

APPROVAL:

R. D. Martin 8/17/70

R.D. Martin
Chief, Transducer Systems Section

R.B. Upson

R.B. Upson
Chief, Laboratory Branch